FINAL
WELL R-26 COMPLETION REPORT
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 37151
Revision No. 1

Prepared for:

The United States Department of Energy and the
National Nuclear Security Administration through the
United States Army Corps of Engineers
Sacramento District

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	below ground surface
DOE	United States Department of Energy
DTH	down-the-hole
DTW	depth to water
DVD	digital video disc
EES	Earth and Environmental Sciences
ELAN	Elemental Analysis
EnviroWorks	EnviroWorks, Inc.
ft	feet
g	grams
gal.	gallon
g/cc	grams per cubic centimeter
GEL	General Engineering Laboratories
hr	hour
HSA	hollow-stem auger
ID	inner diameter
in.	inches
KA	Kleinfelder, Inc.
KBr	potassium bromide
LANL	Los Alamos National Laboratory
MDL	Method Detection Limit
mil	1/1000 of an inch
MP	multiport
NAD	North American Datum
NGS	natural gamma spectroscopy
NMED	New Mexico Environment Department
NOI	Notice of Intent
NTU	nephelometric turbidity unit
OD	outer diameter

psi	pounds per square inch
PVC	polyvinyl chloride
Qbog	Guaje Pumice Bed
Qbt	Tsirege Member of Bandelier Tuff
R-26	Well R-26
SAP	Sampling and Analysis Plan
TA	technical area
TD	total depth
TLD	triple detector lithodensity
TOC	total organic carbon
μS/cm	microsiemens per centimeter
WDC	WDC Exploration & Wells, Inc.

ABSTRACT

Well R-26 was installed at Los Alamos National Laboratory (LANL) for LANL's Groundwater Protection Program as part of the "Hydrogeologic Workplan" (LANL 1998). The Department of Energy (DOE) contracted and directed the installation of Well R-26. The purpose of the well is (1) to characterize intermediate-depth perched groundwater penetrated by existing wells R-25 and SHB-3, and (2) to provide background water chemistry for perched and regional groundwater upgradient of LANL activities in the Technical Area (TA)-16 vicinity. Well R-26 is located on the downthrown block of the Pajarito fault system; data from this well will be used to evaluate the influence of the Pajarito fault system on the regional aquifer piezometric surface and to provide information on the role of faults in recharge.

The well was drilled in two phases. Phase I consisted of collecting continuous core from the surface to a depth of 250 feet (ft) below ground surface (bgs). Core will be used characterize anion profiles in the vadose zone. In Phase II drilling, a borehole was advanced to a total depth (TD) of 1,490.5 bgs into the regional aquifer and installing a well. The well was sampled to determine water quality, and hydrologic testing was conducted to evaluate aquifer parameters.

The R-26 borehole was drilled using fluid-assisted air-rotary and mud-rotary drilling methods. The 5-inch outer diameter stainless-steel well was installed on October 18, 2003, to a TD of 1,479 ft bgs with two screened intervals; the upper screened interval was set within the intermediate-depth perched groundwater, and the lower screened interval was set in the regional aquifer. A Westbay multi-port sampling system was installed on July 16, 2004 for long-term monitoring of water levels and collection of groundwater samples. The stratigraphy encountered during borehole drilling included, in descending order, alluvium, ash-flow tuffs of the Tshirege Member of the Bandelier Tuff, Cerro Toledo interval, ash-flow tuffs of the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed of the Otowi Member, and Puye Formation sediments.

Samples of drill cuttings were collected at regular intervals for stratigraphic, petrographic, and geochemical analysis. A perched water zone was encountered in the R-26 corehole at 240 ft bgs in the Tshirege Member of the Bandelier Tuff. A groundwater sample was collected at 240 ft bgs and was submitted for analysis. Groundwater saturation was first noted while drilling at 650 ft bgs. A groundwater screening sample was collected at 604 ft bgs and was submitted for analysis. Groundwater samples were collected from the completed well's upper screen at 651.8 to 669.9 ft bgs and from the lower screen at 1,421.8 to 1,445 ft bgs. All samples were analyzed for organic, inorganic, and radiochemical compounds.

1.0 INTRODUCTION

This completion report summarizes the drilling, well construction, well development, and related activities conducted from August 27, 2003 to July 18, 2004 to characterize Well R-26 (R-26). R-26 was drilled and installed for Los Alamos National Laboratory's (LANL's) Groundwater Protection Program as part of the "Hydrogeologic Workplan" (LANL 1998). Characterization and sampling activities were conducted in accordance with the SAP (Sampling and Analysis Plan) for Drilling and Testing Characterization Wells R-2, R-4, R-11, and R-26 (LANL 2003). R-26 is located in Cañon de Valle, just east of State Highway 4 and upgradient of LANL activities at Technical Area (TA)-16. The locations of R-26 and adjacent wells are shown in Figure 1.0-1. An electronic copy of this report and appendixes is included on the CD on the inside back cover.

R-26 was funded and directed by the U.S. Department of Energy (DOE). Kleinfelder, Inc. (KA), under contract to the United States Army Corps of Engineers (USACE), was responsible for executing the drilling, installation, testing, and sampling activities with technical assistance from LANL.

The information presented in this report was compiled from field reports and activity summaries generated by KA, LANL, and subcontractor personnel, such as Schlumberger, who provided geophysical logging services and data interpretation. Results of these activities are discussed briefly and shown in tables and figures contained in this report.

R-26 is designed to provide water quality and water level monitoring data from the regional aquifer. R-26 will provide hydrologic and water-quality data for regional groundwater upgradient of potential contaminant sources in TA-16. Data from R-26 and other hydrogeologic data will provide a basis for evaluating the need for groundwater monitoring and will form the technical basis for the design of a groundwater monitoring system. Water quality, geochemical, hydrologic, and geologic information obtained from R-26 will augment knowledge of regional subsurface characteristics and will serve as a monitoring well upgradient of potential release sites.

2.0 PRELIMINARY ACTIVITIES

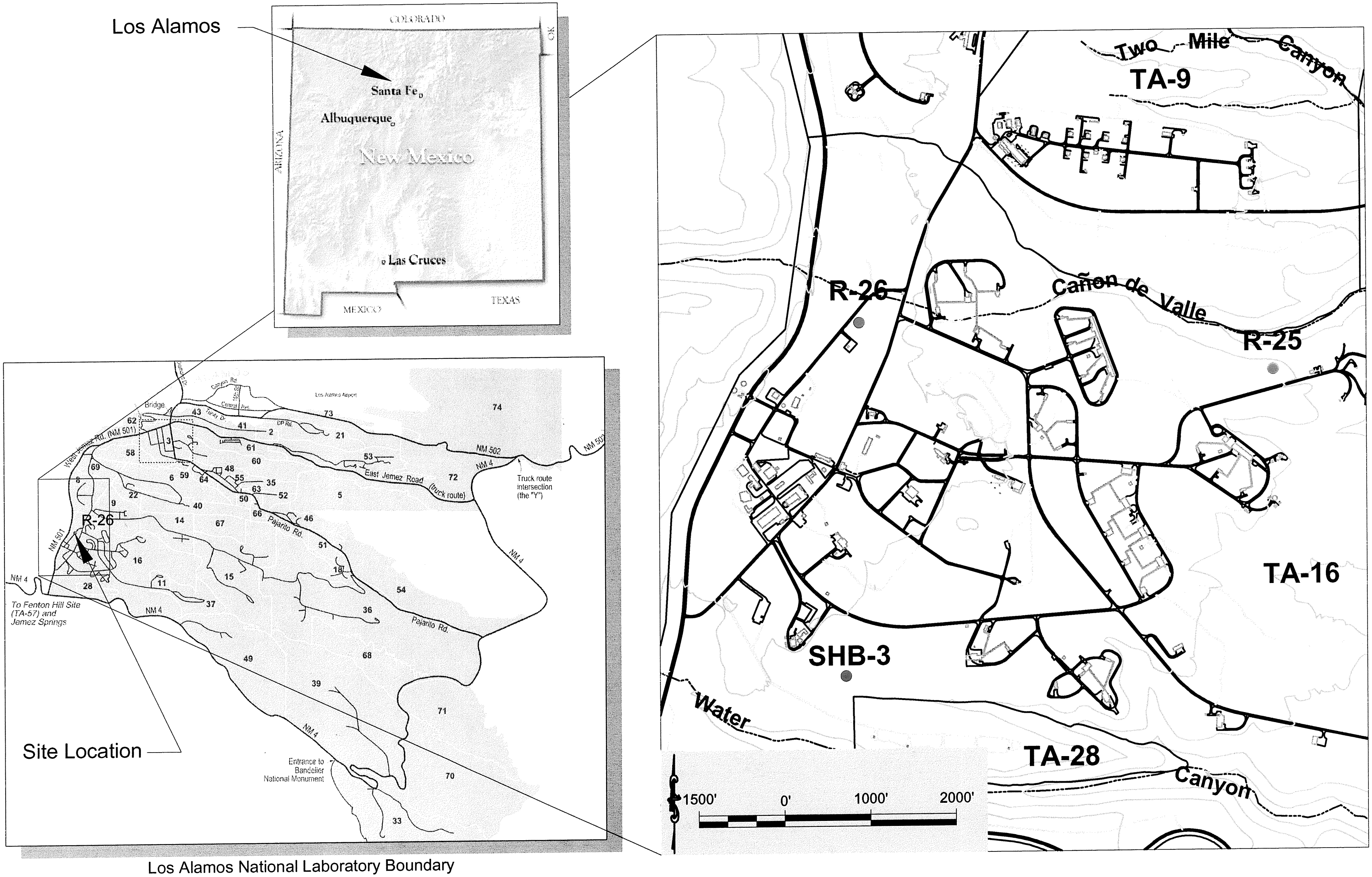
Preliminary activities at R-26 included administrative and site preparation.

2.1 Administrative Preparation

On July 11, 2003, KA received contractual authorization, in the form of a notice to proceed, to start administrative preparation tasks. As part of this preparation, KA developed a Project Management Plan (KA 2003a), a Contractor's Quality Management Plan (KA 2003b), a Site-Specific Health and Safety Plan (KA 2003c), a traffic control plan, and a Drilling Plan (KA 2003d) for the work at Well R-26. The host facility signed a Facility-Tenant Agreement to provide access and security controls for site preparation, drilling and well installation activities. Necessary permits and access agreements were obtained before beginning fieldwork.

2.2 Site Preparation

EnviroWorks, Inc. (EnviroWorks) was subcontracted by KA to prepare the site. Activities included site clearing, access road improvement, construction of the drill pad, and construction of a lined borehole-cuttings containment area. Site preparation was begun on August 27, 2003 and was completed on September 16, 2003.



Observation Well   R-26 Characterization Well   Existing R Characterization Wells

KLEINFELDER		SITE LOCATION MAP Well R-26 Location LANL Well Program Los Alamos National Laboratory Los Alamos, New Mexico	FIGURE 1.0-1
Drawn By: C. Landon	Date: April 2004		
Project No.: 37151	Filename: FIGURE 1.0–1		
Scale: 1" = 2000'	Revision: 0		

Note: R-26 Well Identification Modified from Proposed R Characterization Well Location Map Provided by Los Alamos National Laboratory

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The site was initially cleared of vegetation. The drilling pad was then developed by grading an area with a front-end loader. A primary layer of base-course gravel was distributed over the drill pad area. To store Well R-26 drilling fluids and borehole cuttings, a 30-feet (ft) -wide by 60-ft-long by 7-ft-deep borehole-cuttings containment pit was excavated along the eastern drill pad boundary. A secondary containment area was lined with 6-mil (1/1000 of an inch) polyethylene and surrounded by straw bales to accommodate a 21,000-gallon (gal.) tanker trailer used for storing development water and drilling fluids pumped from the borehole-cuttings containment area. Drill pad construction was completed with an additional graded layer of base-course gravel. Safety barriers and signs were installed around the borehole-cuttings containment area and at the site entrance. Office and supply trailers, generators, and safety lighting equipment were moved to the site during subsequent mobilization of drilling equipment. Base course was also placed on the access road, as necessary. Equipment necessary for the completion of the drilling project was situated at the work site to provide a safe, secure work site. Orientation and placement of the equipment was dependent on borehole location and physical constraints at the drill site.

Potable water for drilling at Well R-26 was pumped from a hydrant adjacent to the fire station located off West Jemez Road and delivered to the site through a fire hose.

3.0 SUMMARY OF DRILLING ACTIVITIES

Drilling activities at Well R-26 were completed in two phases during September and October 2003. Phase I drilling was performed by KA using a StrataStar SS15 drill rig equipped with a 2-ft-long split spoon used to collect 2.0-in.-diameter samples, a 5-ft-long core barrel used to collect 3.0-in.-diameter continuous core samples, and an HQ sampler to collect 2.4-in.-diameter core samples. Phase II drilling was performed in an offset borehole by WDC Exploration and Wells, Inc. (WDC) using a Dresser T70W drill rig equipped with conventional circulation drilling rods, tricone bits, down-the-hole (DTH) hammer bits, and support equipment. Drilling fluid mixing and circulation equipment included a mixing tank and pump assembly, an auxiliary pump, a shaker unit to remove solids from the discharged drilling fluids, and a generator to power the mixing unit.

The goal of Phase I drilling was to collect continuous rock core samples for geologic characterization and to determine moisture, anion, stable isotope, radionuclide, metals, and tritium distributions in the upper section of the borehole. Planned total depth (TD) for Phase I was 250 ft bgs, or approximately 250 ft into the Tshirege Member of the Bandelier Tuff. Groundwater samples were to be collected from significant perched zones, if encountered.

Drilling of the borehole for Phase II was performed using air-rotary, fluid-assisted air-rotary, and mud-rotary drilling techniques using open-hole and casing-advance methods, as appropriate for changing geologic and drilling conditions. Various additives were mixed with municipal water to improve borehole stability, to minimize fluid loss, and to facilitate cuttings removal from the borehole. Air-rotary drilling was assisted with water at shallow depths to suppress dust emissions and, at greater depths, with a foam mixture that consisted of municipal water mixed with QUIK-FOAM® (surfactant) and EZ-MUD® (polymer). Mud-rotary drilling fluids were comprised of a mixture of water, bentonite, soda ash, and Pac-L polyanionic cellulose.

Primary Phase II drilling objectives were (1) to collect cuttings of encountered geologic formations; (2) to collect water samples from perched and regional groundwater zones; (3) to complete a borehole for geophysical logging; and (4) to install a well with two screened intervals, one in the intermediate perched zone, if present, and one in the regional aquifer. The planned TD for Phase II drilling was approximately 1,414 ft bgs, roughly 100 ft below the predicted regional water table.

Coring and deep drilling activities were conducted from September 8 through October 17, 2003. Phase I drilling was completed in one shift per day from September 8 through September 12, 2003. Phase II drilling activities were performed generally in one shift per day from September 18 through October 14, 2003. Two shifts per day began on October 14 and continued through October 21, 2003, during well construction. A drill shift nominally represents a 12-hour (hr) period spent on the project by the drill crew, two site geologists, and onsite support equipment. Drilling and well construction work was conducted under a 7-days-per-week schedule.

Figure 3.0-1 summarizes well data and graphically depicts groundwater and geologic conditions encountered in R-26. Sections 3.1 and 3.2 discuss Phase I and Phase II drilling activities, respectively, for R-26.

A tabular chronology of drilling and other onsite activities is presented as Table 3.0-1.

3.1 Phase I Drilling Activities

On September 8, 2003, KA mobilized a StrataStar SS15 hollow-stem auger (HSA) drill rig and support equipment to the R-26 site and began Phase I core drilling. The corehole drilling was initiated with an 8-in. nominal outer diameter (OD) HSA using a DTH hammer with a split-spoon sampler. At 19 ft bgs, KA switched to the continuous sampler system to achieve optimal core recovery. This proved ineffective, and drilling and sampling with the split-spoon sampler was resumed at 25 ft bgs. Split-spoon sampling proved to be difficult from 25 ft to 31 ft bgs.

At 31 ft bgs, KA switched to an air-assisted drilling method using a conventional 3-in. OD core barrel attached to an HQ drill rod. Dust suppression equipment was installed. Coring from 31 ft to 55 ft bgs yielded poor recovery. On September 10, 2003, KA reverted to split-spoon sampling and advanced the hole from 55 ft to 65 ft bgs with limited recovery. Coring with the conventional core barrel was resumed at 65 ft bgs for drilling in the strongly welded tuff. At 70 ft bgs, the drillers replaced the conventional core barrel with a Geobarrel® and cored continuously to 145 ft bgs, where the Geobarrel® core bit was replaced due to excessive wear. Equipped with a new coring bit, the drillers returned to conventional core barrel techniques and advanced the core hole from 145 ft bgs to the planned TD of 250 ft bgs.

On September 15, 2003, the drillers tripped out the drill stem, and video, natural gamma, and resistivity logs were run in the corehole. The video log (Appendix A) revealed possible perched zones of saturation from 150 to 180 ft bgs and 230 to 250 ft bgs. Depth to groundwater was measured at 242 ft bgs in the corehole. A groundwater screening sample was collected from the open corehole at 240 bgs on September 18, 2003, and was submitted for analysis. Two piezometers were installed with screened intervals in the potential zones of saturation. Further discussion on the piezometer installation is in Section 7.3.

Location: Mesa South of Cañon de Valle
(on down thrown side of Pajarito Fault) TA-16

Description: Brass Marker
Northing: 1764721.12
Easting: 1610267.33
Elevation: 7641.69

Description: Well Casing
Northing: 1764721.35
Easting: 1610269.56
Elevation: 7643.33

Coring:
(0' - 31') Auger
(31'-55') HQ Coring
(55' - 65') Auger
(65' - 250') HQ Coring

Drilling:
(0' - 77') 13-3/8" Air Rotary Casing Hammer
(77' - 140') 12-1/4" Tri-Cone, Air-rotary
(140' - 205') Air-rotary with water
(205' - 1005') Fluid-assisted (AWQE) air rotary
(1005' - 1490.5') Mud-rotary 8.5" Tri-Cone

Reaming:
(77' - 1005') 14" Roller Reamed - unsuccessful
(1005' - 1490') 10" Reamed - partial success

Data Collection:
- Hydrologic Properties:
  Constant discharge pumping test: 2/11/04 - 2/27/04
- Cores/Cuttings submitted for geochemical and contaminant characterization: 13
- Ground Water Samples Submitted
  Perched Ground Water - 9/18/03 (240') - corehole
  Deep Ground Water -
  Screening Samples: 9/22/03 (604')
  Well Samples: 11/14/03 (1430')
  11/16/03 (660')
- Geologic Properties:
  Cuttings submitted for mineralogy, petrography, and chemistry: 7

Borehole Logs:
- Lithologic: 0' - 1490.5'
- Video (LANL tool): 0' - 717'
- Caliper Logging: 0 - 1475'
- Schlumberger logs:
  Compensated Neutron Log:
  9/28/03: Open Hole: 70'-985'
  10/14/03: Cased: 500'-1005'; Open Hole: 1005'-1481'
  Triple Litho-Density:
  9/28/03: Open Hole: 70'-985'
  10/14/03: Cased: 500'-1005'; Open Hole: 1005'-1481'
  Array Induction Imager:
  9/28/03: Open Hole: 70'-979'
  10/14/03: Cased: 500'-1005'; Open Hole: 1005'-1476'
  Elemental Capture Sonde:
  9/28/03: Open Hole: 70'-981'
  10/14/03: Cased: 500'-1005'; Open Hole: 1005'-1477'
  Natural GR Spectroscopy:
  9/28/03: Open Hole: 70'-979'
  10/14/03: Cased: 500'-1005'; Open Hole: 1005'-1460'
  Combinable Magnetic Resonance:
  9/28/03: Open Hole: 70'-967'
  10/14/03: Cased: none; Open Hole: 1005'-1464'
  Fullbore Formation Micro Imager:
  9/28/03: Open Hole: 450'-985'
  10/14/03: Cased: none; Open Hole: 1005'-1483'

Corehole Logs:
- Lithologic: 0' - 250'
- Video (LANL tool): 0' - 241'
- Gamma Ray (LANL Tool): 0'-245'
- Array Induction (LANL Tool): 0'-245'

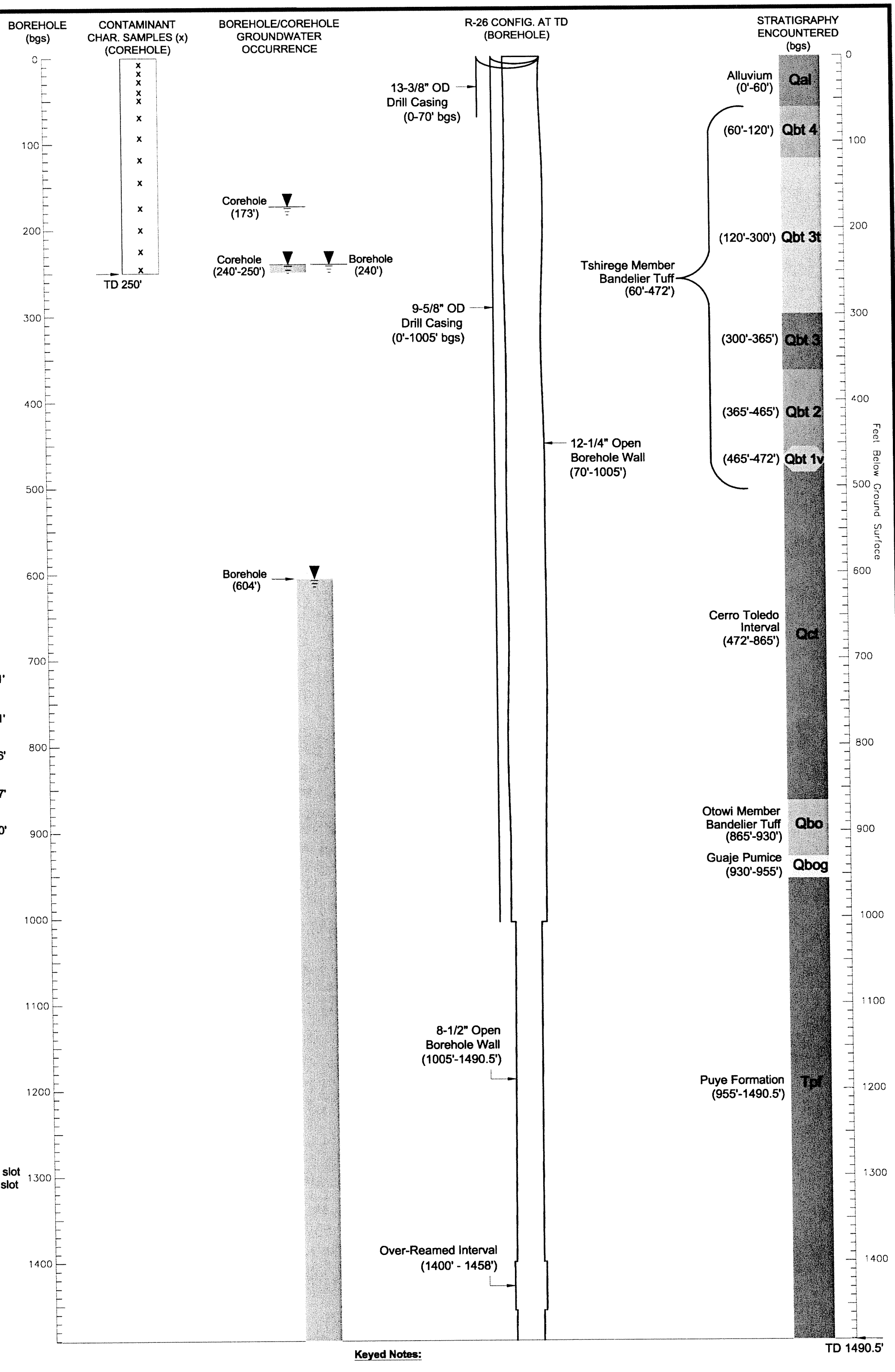
Core Drilling Completed: 9/8/03-9/12/03
Rotary Drilling Completed: 9/18/03-10/17/03
Contract Geophysics: 9/28/03 and 10/14/03-10/15/03
Well Installation: 10/17/03-10/21/03
Well Developed: 10/29/03-11/16/03

- Casing:
  4.46" ID / 5.0" OD A304 Stainless Steel casing with external couplings
- Number of Screens:
  Two (2) 4.46" ID wire wrapped stainless steel with external couplings.
  Screen #1 (Upper): 5.53" OD Pipe based 0.010 slot
  Screen #2 (Lower): 5.27" OD Rod based 0.020 slot
- Screen Intervals:
  Screen #1 (Upper): 651.8' - 669.9'
  Screen #2 (Lower): 1421.8' - 1445'

Well Development performed by airlifting, swabbing, bailing, and pumping.
Total Volume Purged: 41,069 gallons

Corehole Temporary Piezometer Completions
- Casing - 1" OD Sched. 40 PVC threaded
- Number of Screens - One (1) 1" OD Sched. 40 PVC 0.010 slotted in each piezometer
- Screen Interval -
  Piezometer 1 - 230'-250'
  Piezometer 2 - 150'-180'

Geologic contacts for R-26 were determined from core samples, cuttings, borehole video, and geophysical logs.



Keyed Notes:

1. Coordinates - NM State Plane Grid Central Zone (North America) Datum - 1983 (NAD83); expressed in feet.
2. Elevations - National Geodetic Vertical Datum (NGVD29); expressed in feet above mean sea level.
3. All depths are below ground surface (bgs).
4. Drill casing removed prior to well installation.
5. Borehole reamed across Screen #2 Interval (1421.8'-1445')
6. Water level measurement in shallow piezometer was 172.97'; the deep piezometer was dry when sounded on 11-25-03.
7. Post-development composite groundwater level measurement recorded on 9-21-03.

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Drawn By: C. Landon	Date: January 2005
Project No.: 37151	Filename: Figure 3.0-1.dwg
Scale: not-to-scale	Revision: 4

WELL SUMMARY DATA SHEET
Well R-26
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
3.0-1

TABLE 3.0-1. OPERATIONS CHRONOLOGY GRAPH FOR WELL R-26

TASK DESCRIPTIONS	DATE											
	August-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04
SITE PREPARATION ACTIVITIES	8/27	9/16										
COREHOLE DRILLING AND SAMPLING		9/8										
Mobilization		9/8										
Continuous Coring		9/8 9/12										
LANL Video & Geophysics		9/15										
Plug & Abandon Corehole												
BOREHOLE DRILLING AND SAMPLING		9/17	10/17									
Mobilization		9/17										
Air Rotary		9/18										
Fluid Assisted Air Rotary		9/19										
Mud Rotary		9/20	10/17									
Groundwater Screening Sampling		9/18, 9/21-22										
BOREHOLE GEOPHYSICS		9/22	10/16									
Schlumberger Logging		9/28	10/14-15									
LANL Video		9/15 9/22										
LANL Geophysics			10/16 10/17									
WELL DESIGN AND CONSTRUCTION			10/17-21									
WELL DEVELOPMENT			10/18	11/17								
GROUNDWATER WELL SAMPLING				11/14 11/16								
HYDROLOGIC TESTING							2/16 2/27	3/6				
SITE RESTORATION									4/4-8			7/16-18
WESTBAY INSTALLATION												

NOTES:
Shaded area indicates no activity

3.2 Phase II Drilling Activities

On September 17, 2003, WDC mobilized a Dresser T70W drill rig, compressor and, support equipment to the site for Phase II drilling. The Phase II borehole was located 91 ft northeast of the corehole. On September 18, 2003, the WDC drill crew advanced 13⅜-in. OD drill casing to 65 ft bgs with a 12¼-in. tricone drill bit. The borehole was drilled ahead of the drill casing to 77 ft bgs.

On September 19, 2003, WDC drove the 13⅜-in. conductor casing to 70 ft bgs, then advanced the borehole with the 12¼-in. tricone drill bit and air-rotary methods from 77 ft bgs to 140 ft bgs. The drillers switched to a 12¼-in. DTH hammer bit with air only and drilled open-hole to 147 ft bgs. The borehole was checked for the presence of groundwater at the end of the shift and at the start of work on September 20, 2003; none was present. Open-hole air-rotary drilling resumed at 147 ft bgs, and water was used for dust suppression.

On September 20, 2003, at approximately 205 ft bgs, drilling fluids consisting of QUIK-FOAM® and EZ-MUD® and potable water were used to facilitate cuttings removal and borehole stabilization. Table 3.2-1 shows the total amount of drilling fluids introduced and recovered from the borehole during Phase II drilling activities. The borehole was advanced through the Tshirege Member of the Bandelier Tuff and into volcaniclastic sediments and pumice beds of the Cerro Toledo interval to 565 ft bgs.

Table 3.2-1
Introduced and Recovered Drilling Fluids

Material	Unit	Amount
QUIK-FOAM®	Gallon	31
EZ-MUD®	Gallon	3.25
Potable Water	Gallon	23,690
Drilling Mud[1]	Gallon	95,500
Recovered Fluids[2]	Gallon	53,856

[1] Drilling Mud is a mixture of water, bentonite, soda ash and Pac-L polyanionic cellulose
[2] Recovered fluids represents approximate fluids recovered during drilling based on pit dimensions. Fluids removed during well development are included in Table 8.1-1.

On September 21, 2003 a measured depth-to-water (DTW) indicated that the borehole was dry. Drilling resumed open hole using air and a mixture of potable water, EZ-MUD® and QUICK-FOAM®. At 650 ft bgs, observations of the drilling discharge indicated the potential presence of groundwater. The borehole was advanced to 720 ft bgs, where drilling was halted and all tools were tripped out of the borehole. DTW measurements indicated groundwater stabilized after approximately one hour at 604.3 ft bgs. A groundwater screening sample was collected for chemical analysis with a stainless-steel bailer, and the site was secured for the day.

At the beginning of the shift on September 22, 2003, the DTW was measured at 604.2 ft bgs. A second groundwater sample was then collected for chemical analysis with a stainless-steel bailer and the video camera was deployed in the open borehole to document subsurface conditions.

Fluid-assisted drilling resumed open-hole from 720 ft bgs to 900 ft bgs in Cerro Toledo sediments and the Otowi Member of the Bandelier Tuff using a 12¼-in. mill-tooth tricone bit. On the morning of September 23, 2003, the DTW was measured at 611.7 ft bgs. The drillers advanced the borehole from 900 ft through the Guaje Pumice Bed and into the clastic sediments of the Puye Formation to 1,000 ft bgs using a 12¼-in. tricone button bit with fluid-assisted air-rotary drilling methods. At 1,000 ft bgs, WDC elected to switch to the mud-rotary drilling method because of increased borehole sidewall instability.

On September 24 and 25, 2003, WDC mobilized a shaker table and other equipment to prepare for mud-rotary drilling. The New Mexico Environment Department (NMED) approved all mud-drilling additives. On September 25, 2003, three 1,500-gal. batches of drilling mud were mixed and pumped into the borehole. A single batch of drilling mud consisted of 1500-gal. of water, 12 to 22 bags of Aqua-Gel powdered bentonite, 8 quarts of Pac-L (Drispack) and 10 pounds of soda ash. Drilling mud-batch mixing continued through September 26 and 27, 2003. By the end of the shift on September 27, 42,000 gal. of drilling mud had been pumped into the borehole. The calculated capacity of the borehole was 5,932 gal. The top of the mud was last measured at 170 ft bgs, indicating that substantial fluid loss was occurring from the borehole. A total of 7 bags of N-Seal (lost circulation material) had been added to the last five batches of the day to attempt to mitigate the fluid loss from the borehole.

On September 28, 2003, Schlumberger arrived onsite and ran geophysical logging tools described in Section 5.0.

On September 29, 2003, WDC attempted to run 11¾-in. threaded drill casing into the borehole to prevent further fluid loss problems in the borehole. An imperfection in the borehole prevented the 11¾-in. drill casing from being lowered past 131.5 ft bgs. The imperfection was possibly either a slight deviation in the alignment of the borehole or a rock ledge. The borehole was subsequently reamed to 160 ft bgs with a 12½-in. tricone bit in an attempt to remove the imperfection; however, the 11¾-in. casing could not be lowered or pushed past 135 ft bgs when installation was reattempted. On September 30 and October 1, 2003, WDC reamed the entire borehole from ground surface to 1,005 ft bgs with an 8-in. tricone drill bit and an 8-in. roller-reamer bit positioned above the drill bit. The roller-reamer bit was capable of expanding to a maximum effective diameter of 14-in. However, drill rig pump pressures were not sufficient to achieve the maximum reaming diameter. Water and QUIK FOAM® were used to ream the borehole. On October 2, 2003, DTW was measured at 606 ft bgs and the 11¾-in. drill casing was tripped in for a third time to approximately 135 ft bgs, where it once again encountered the imperfection that prevented further advancement of the casing.

A decision was made to install smaller-diameter drill casing that would theoretically bypass the obstruction. On October 3 and 4, 2003, the 9⅝-in. drill casing was installed to a final depth of 1000 ft bgs. At 0830 on the morning of October 4, 2003, the drill crew began days off. On October 10, 2003, drilling operations resumed. WDC mixed and pumped three 1,500-gal. batches of drilling mud into the cased borehole. The batches consisted of water, 10 bags of bentonite, 10 bags of soda ash, and 6 quarts of Pac-L polyanionic cellulose. At approximately 980 ft bgs, while reaming the 9⅝-in. drill casing with the 8½-in. tricone button bit, the drill casing slipped down 5 to 1,005 ft bgs. On the following day, WDC reamed cuttings from the casing and drilled open-hole from 1,005 to 1,145 ft bgs in the Puye fanglomerate using the 8½-in. tricone button bit and mud-rotary techniques.

On the morning of October 11, 2003, the borehole was reamed and drilling resumed. Drilling continued open-hole using the same equipment and methods until October 14, 2003, when the borehole had been advanced to 1,485 ft bgs. Schlumberger mobilized borehole geophysical logging equipment to the site the same day and gathered borehole geophysical data, which are described in Section 5.0. On October 15, 2003, WDC set up to ream the borehole with a 4½-in. tricone pilot bit with a 2½-in. side reamer using mud-rotary methods. The crew worked through the night, and on October 16, 2003, had reamed the borehole to 1,485 ft bgs, still within the Puye Fanglomerate, and had over-drilled an additional 5 ft to 1,490.5 ft bgs, the TD of the borehole. The LANL geophysics trailer was mobilized to the site to run the borehole caliper to verify that the borehole diameter was sufficient to build a monitoring well with the required 2-in. annulus. Caliper data indicated that the borehole diameter was 8.5-in. within the vicinity of the planned well-screen interval, too small to provide the required 2-in. annulus for a 5-in.-diameter well screen (caliper log on compact disk [CD], inside back cover). WDC subsequently reamed the borehole again from 1,400 to 1,475 ft bgs with the 14-in. hydraulic roller-reamer and 4.5-in. tricone pilot bit. After the borehole had been reamed to 1,485 ft bgs, caliper data indicated that the borehole measured at least 9.3-in. in diameter throughout the planned lower screened interval of the monitoring well (caliper log on CD, inside back cover). Phase II drilling was completed on October 17, 2003, and well construction preparations commenced.

4.0 SAMPLING AND ANALYSIS OF DRILL CUTTINGS AND GROUNDWATER

4.1 Sampling of Drill Cuttings and Core

During drilling operations at R-26, drill cuttings were collected according to the LANL-prepared Sampling and Analysis Plan (LANL 2003). As drilling conditions permitted, an ample quantity of borehole material was collected from the discharge line at 5-ft intervals. A portion of the cuttings was sieved (at >#10 and >#35 mesh, or >#35 and >#60 for finer-grained samples) and placed in chip-tray bins along with an unsieved portion. These chip trays were studied to determine lithologic characteristics and were used to prepare the lithologic logs. The remaining cuttings were sealed in Ziploc® bags and set in core boxes for curation. Seven samples were removed by LANL for mineralogic, petrographic, and geochemical analyses. No cuttings samples were submitted for contaminant characterization analysis.

Core samples were collected from R-26 and analyzed for cations, anions, metals, and radionuclides for characterization purposes. Thirteen samples of core were collected from the vadose (unsaturated) zone during drilling from 5 ft to 250 ft bgs. Approximately 500 grams (g) to 1,000 g of core samples were placed in appropriate sample jars and protective plastic bags before being delivered to Earth and Environmental Sciences (EES)-6, Coastal Science Laboratories, Inc., and General Engineering Laboratories (GEL) for laboratory analysis. Analytical results will be included in future investigation reports for Cañon de Valle.

4.2 Sampling of Groundwater

During Phase I drilling operations at R-26, perched groundwater was encountered at 240 ft bgs, and a groundwater screening sample was collected on September 18, 2003, from the corehole for analysis. Groundwater samples have not been collected from the temporary piezometers.

During Phase II drilling operations, groundwater was first encountered at 650 ft bgs on September 21, 2003. After the borehole was advanced to 720 ft bgs, the water table was measured at 604 ft bgs. At this stage, the drill system was removed from the borehole, and a groundwater screening sample was collected using a wireline bailer. On the morning of September 22, 2003, the DTW was measured at 604 ft bgs, and a second groundwater screening sample was collected from the open borehole. Because the second sample contained less suspended sediment, it was submitted for analysis and the first sample was disposed of.

Although the regional water table was predicted to occur at 1,314 ft bgs, neither the drillers nor the onsite geologists were able to distinguish between the increased flow detected from the drilling discharge line at approximately 600 ft bgs and groundwater in the regional aquifer. Geophysical log interpretation suggests that full saturation does not occur until the Puye Formation is encountered at 955 ft bgs (see Section 5.2 and Appendix B, Schlumberger's Geophysical Report and Montages, for further discussion). During well development activities, two groundwater samples were collected from the completed well R-26 on November 14 and 16, 2003. With a packer isolating the two screened intervals, these samples were collected from 1,430 ft and 660 ft bgs, respectively, and were submitted for analysis.

Further discussion of the groundwater sampling and analytical results are presented in Appendix C.

5.0 BOREHOLE GEOPHYSICS

Using LANL-owned and subcontractor-owned tools, KA and Schlumberger performed borehole geophysics logging operations at R-26.

5.1 KA-Supported Geophysical Logging

On September 15, 2003, video, natural gamma, and resistivity logging were performed in the R-26 corehole using downhole tools provided by LANL. The logs were used to look for perched water and to aid in lithologic contact identification. On September 22, 2003, video logging was performed in borehole R-26 using downhole tools provided by LANL. On October 16, 2003, caliper logging was performed in the borehole to determine whether the borehole diameter was sufficient for well screen installation. On October 17, 2003, after the borehole was reamed, caliper logging was rerun to confirm that the borehole was of sufficient diameter.

Table 5.1-1 summarizes the video and geophysical well logs conducted in R-26. The video logs of the open borehole were digitized onto the two digital videodiscs (DVDs) that are included as Appendix A. The gamma, resistivity, and caliper logs are included on the CD included on the back inside cover of this report.

Table 5.1-1
Borehole and Well Logging Surveys Conducted in R-26

Operator	Date	Method	Cased Footage (ft bgs)	Open-hole Interval (ft bgs)	Remarks
KA/LANL	September 15, 2003	Video	0-65	65-241	Corehole video to identify accumulated water
KA/LANL	September 15, 2003	Gamma and Resistivity Log	0-65	65-245	Corehole logging
KA/LANL	September 22, 2003	Video	0-70	70-717	Open-borehole video
Schlumberger	September 28, 2003	Logging suite[a]	0-70	70-985[b]	Schlumberger borehole logging conducted on open hole before installing casing
Schlumberger	October 14 and October 15, 2003	Logging suite[a]	0-1005	1005-1477[b]	Schlumberger borehole logging conducted to TD before well installation
KA/LANL	October 16, 2003	Caliper Log	0-1005	977-1459	Borehole logging to determine diameter before well installation
KA/LANL	October 17, 2003	Caliper Log	0-1005	1374-1474	Borehole logging to determine diameter before well installation

[a] Schlumberger suite of borehole logging surveys included triple detector litho-density, array induction tool, epithermal compensated neutron tool, elemental capture spectrometry, full-bore formation microimager, combinable magnetic resonance tool, natural gamma spectrometry, caliper gamma ray, spontaneous potential, and platform express.

[b] Variable effective depths, see Appendix A.

5.2 Schlumberger Geophysical Logging

The primary purpose of the Schlumberger logging was to characterize the conditions in the hydrogeologic units penetrated by the R-26 borehole, with emphasis on gathering moisture distribution data, identifying possible perched water zones, measuring capacity for flow (porosity and moisture), and obtaining lithologic/stratigraphic data. Secondary objectives included evaluating borehole geometry and determining the degree of drilling fluid invasion along the borehole wall.

Schlumberger personnel conducted geophysical logging in the R-26 borehole on September 28 and again on October 14 and 15, 2003. During the initial geophysical logging, a 13⅜-in. OD drill casing extended from the ground surface to 70 ft bgs, and the remainder of the borehole was open to 985 ft bgs. During the second run of geophysical logging, a 13⅜-in. OD drill casing extended from the ground surface to 70 ft bgs, and a 9⅝-in. OD steel drive casing extended from the surface to 1,005 ft bgs; the remainder of the hole was open to 1,485 ft bgs.

Schlumberger personnel ran a suite of geophysical logging tools in the cased and uncased portions of the borehole. The suite included the following tools:

- Combinable Magnetic Resonance™ tool measures the nuclear magnetic resonance response of the formation. It is used to evaluate total and effective water-filled porosity of the formation and to estimate pore-size distribution and in-situ hydraulic conductivity.
- Array Induction Tool, version H™, measures formation electrical resistivity and borehole fluid resistivity, thus evaluating the drilling fluid invasion into the formation, the presence of moist zones away from the borehole wall, and the presence of clay-rich zones.
- Triple Detector Litho-Density™ measures formation bulk-density related to porosity, photoelectric effect related to lithology, and borehole diameter using a single-arm caliper.
- Natural Gamma Spectroscopy (NGS™) measures spectral and overall natural gamma-ray activity, including potassium, thorium, and uranium concentrations, thus evaluating geology and lithology.
- Elemental Capture Spectroscopy™ measures concentrations of hydrogen, silicon, calcium, sulfur, iron, aluminum, potassium, titanium, chlorinity, and gadolinium to characterize mineralogy, lithology, and water content of the formations.
- Epithermal Compensated Neutron Tool, model G™, measures volumetric water content beyond the casing to evaluate formation moisture content and porosity.
- Full-Bore Formation Micro-Imager (FMI™) measures electrical conductivity images of the borehole wall and the borehole diameter with a two-axis caliper to evaluate geologic bedding and fracturing, including strike and dip of these features, fracture apertures, and rock textures.

Additionally, a calibrated natural gamma tool was used to record gross natural gamma-ray activity with each logging method (except the NGS™ run) to correlate depth runs between each of the surveys conducted.

The Schlumberger interpretive logging report and the geophysical logs, compiled as a montage, can be found as Appendix B (compact disc included). Additionally, an abstract of Schlumberger's report is presented in Appendix B on pages B-1 and B-2.

6.0 LITHOLOGY AND HYDROGEOLOGY

A preliminary assessment of the hydrogeologic features encountered during drilling operations at R-26 is presented below. Groundwater occurrences are discussed based on drilling evidence, open-hole video logging, and geophysical logging data. LANL EES-6 staff provided preliminary geologic contacts.

6.1 Stratigraphy and Lithologic Logging

Rock units and stratigraphic relations, interpreted primarily from visual examination of rock core, sampled drill cuttings, and geophysical data, are briefly discussed in order of younger to older occurrence. These interpretations may be revised upon further analysis of petrographic, geochemical, mineralogical, and geophysical data. A lithology log for the R-26 borehole is provided in Appendix D.

Alluvium (0 to 60 ft bgs)

Core samples indicated that unconsolidated alluvium was intersected in R-26 from ground surface to approximately 60 ft bgs. This interval is made up of clastic sediments, including tuffaceous silty sands and gravels as well as weathered boulders and blocks of indurated ash flow tuff. The sedimentary constituents are likely derived from the Tshirege Member of the Bandelier Tuff and Tschicoma dacite lavas.

Bandelier Tuff (60 to 955 ft bgs)

The Bandelier Tuff is locally represented in borehole R-26 in the interval from 60 to 955 ft bgs by the Tshirege (Qbt) and Otowi Members, including the Guaje Pumice Bed at the base of the section. An unusually thick section of the Cerro Toledo interval was identified between the Tshirege and Otowi Members from 472 to 865 ft bgs.

Ash flows of the Tshirege Member of the Bandelier Tuff (60 to 472 ft bgs)

Rhyolitic ash flows of the Tshirege Member have been divided into four separate cooling units in the general region of the Pajarito Plateau (Broxton and Reneau, 1995). The drilled R-26 section from 60 to 472 ft bgs is interpreted to represent, in descending order, Units 4, 3t, 3, 2, and 1v. Unit 1g, which is normally present at the base of the Tshirege Member, is absent at R-26. The tuff section is locally typified by strong welding that is characteristic of ash flows occurring in the western part of the plateau.

Unit 4 was intersected from 60 to 120 ft bgs. Core and cuttings samples indicate that Unit 4 is comprised of abundant sanidine and quartz phenocrysts, typically making up 20 to 40% of the sample by volume, and up to 30% pumice lapilli enclosed in a matrix of reddish fine vitric ash. Volcanic lithic fragments (i.e., xenoliths) are locally present in abundances of 1 to 2% by volume. Welding is characterized as weak near the top, possibly due to the effects of weathering, but increases significantly toward the base of the interval.

Units 3t and 3 are represented in the R-26 section from 120 to 300 ft, and from 300 to 365 ft bgs, respectively. Cuttings samples from Unit 3t, a unit having chemical properties transitional between Qbt 3 and Qbt 4, are represented by chips of strongly welded tuff that are typically made up of quartz, sanidine, and minor ferromagnesian minerals (possibly pyroxene), as much as 3% small intermediate volcanic xenoliths, and a well-indurated matrix of light to medium gray vitric ash. Unit 3 appears to be a strongly welded crystal-rich tuff with characteristics that are visually similar to those of Unit 3t.

Cuttings from Unit 2, intersected in R-26 from 365 ft to 465 ft bgs, are made up of light brownish gray, indurated, strongly welded tuff. Crystals (commonly as much as 50% by volume) of sanidine, quartz, and ferromagnesian minerals and small (up to 5 millimeters) felsic and intermediate volcanic lithics (up to 5% by volume) are enclosed in an aphanitic matrix of vitric ash.

Unit 1v occurs from 465 to 472 ft bgs. It is defined by a downward decrease in bulk density toward the base of the Tshirege Member. The contact between the strongly welded tuffs of Unit 2 and the less welded tuffs of Unit 1v is gradational.

Cerro Toledo Interval (472 to 865 ft bgs)

Volcaniclastic sedimentary and tephra deposits of the Cerro Toledo interval regionally separate the Tshirege and Otowi Members of the Bandelier Tuff. Geophysical logs suggest that the Cerro Toledo interval occurs in borehole R-26 from 472 to 865 ft bgs. This unexpectedly thick interval of tuff and volcaniclastic sediments appears to represent a filled paleo-channel incised into the underlying Otowi Member. Cuttings indicate that this volcaniclastic deposit is locally made up of silty to clayey sands and gravels. Detrital constituents comprised of hornblende-biotite dacite, rhyolite, andesite, indurated welded tuff, pumice fragments, and local vitrophyre are present in varying abundances throughout the interval.

Ash flows of the Otowi Member of the Bandelier Tuff (865 to 930 ft bgs)

Ash flows of the Otowi Member of the Bandelier Tuff are recognized in the interval from 865 ft to 930 ft bgs. Cuttings show that the Otowi Member is strongly pumiceous and poorly welded. Pumice fragments in chip samples are vitric and white or orange-brown as a result of iron-oxide staining. Volcanic lithic fragments represent xenoliths of dacite, andesite, rhyolite, and vitrophyre. Free quartz and sanidine crystals are generally abundant in the fine-grained fraction of the sieved cuttings samples.

Guaje Pumice Bed of the Otowi Member (930 to 955 ft bgs)

The Guaje Pumice Bed (Qbog) was encountered in borehole from 930 to 955 ft bgs. Cuttings from this interval indicate the unit is nonwelded and generally pumice-rich. Samples from this unit are typically made up of pumice, quartz, and sanidine crystals, and lithic fragments of intermediate volcanic composition.

Puye Formation (955 to 1490.5 ft bgs)

Fanglomerates of the Puye Formation were intersected in the R-26 interval from 955 ft to the borehole TD at 1490.5 ft bgs. The FMI log (Appendix D) indicates that the Puye Formation largely consists of clast- and matrix-supported conglomerate, with clasts commonly 0.5 to 1.5 ft in diameter. Clasts in these sediments are predominantly made up of detritus, likely derived from volcanic rocks of the Tschicoma Formation, including porphyritic dacite, rhyodacite, rhyolite, andesite, and vitrophyre. Minor occurrences of welded tuff and chert are locally present in the interval.

6.2 Groundwater Occurrence and Characteristics

Perched groundwater saturation zones above the regional aquifer were predicted to occur in R-26 within either the Cerro Toledo interval or the Otowi Member of the Bandelier Tuff, or between 700 and 900 ft bgs. However, during Phase I coring, a shallow zone of perched saturation was first observed at 240 ft bgs within the Tshirege Member of the Bandelier Tuff and before encountering refusal at 250 ft bgs. A video camera survey of the open corehole indicated that water was emanating from a depth of 150 to 180 ft bgs.

Two temporary piezometers were installed side by side in the corehole to collect possible perched groundwater data from two target intervals: an upper screen from 150 ft to 180 ft bgs (piezometer 2) and a lower screen from 230 ft to 250 ft bgs (piezometer 1). On November 25, 2003, approximately 1 month after the installation of the piezometers, the DTW was measured at 173 ft bgs in piezometer 2; however, no water was present in piezometer 1.

An intermediate perched saturated zone was indicated by a sustained increase in flow from the discharge line during Phase II drilling in the Cerro Toledo interval, at approximately 650 ft bgs. A groundwater level measurement of 604 ft bgs was observed on September 21, 2003, when the depth of the borehole was at 720 ft bgs.

The chemical indicator potassium bromide (KBr) was added to drilling fluids when the borehole had been advanced to 200 ft bgs. Monitoring input and output concentrations showed that KBr concentrations were at fairly consistent levels from 300 to 600 ft bgs. KBr concentrations began to decrease significantly at 650 ft bgs, reflecting dilution of the drilling fluids by formational water entry into the borehole. Due to the presence of significant quantities of groundwater in the borehole, KBr monitoring was suspended when the borehole was advanced to 1005 ft bgs.

The processed geophysical logs indicate high water-filled porosity within the porous, glassy tuff/pumice and volcaniclastic sediment sections in R-26 from 575 to 955 ft bgs. However, the processed logs, by themselves, indicate that most of this interval is not fully saturated with water. A water level between 865 ft and 885 ft bgs made when the bottom screen was isolated during hydrologic testing is consistent with these observations. The total porosity in the glassy tuffs/pumice and volcaniclastic sediments, estimated from the elemental analysis (ELAN) integrated log analysis, ranges from 40% to over 50% of total rock volume, with water saturations of generally 50–80%.

The estimated moveable water content is generally high across this water-rich glassy tuff/pumice and volcaniclastic sediment interval ranging from 5 % to 25% of total rock volume. Although much of the 575 to 955 ft bgs interval may not be fully saturated with water, the high total and moveable water content suggests that, in general, the water is quite mobile. The water in this interval is likely connected to the saturated Puye Formation below.

There is strong evidence from the processed geophysical logs that the bottom of Well R-26, below the Guaje Pumice Bed (955 ft bgs) in the Puye Formation, lies within the regional aquifer. The estimated pore volume water saturation (fraction of the total pore volume containing water) computed from the ELAN analysis is over 85% from 954 ft bgs to the bottom of the log interval at 1484 ft bgs. The estimate is even higher when computed directly from bulk density and ELAN water-filled porosity for a grain density range of 2.45 grams per cubic centimeter (g/cc) to 2.65 g/cc, ranging from 90% to a consistent 100%.

The estimated moveable water generally varies from 7% to 15% of total rock volume across the saturated interval. The hydraulic conductivity estimated from the ELAN integrated log analysis (from the CMR moveable water measurement) generally ranges from 0.1–1 gal./day/ft^2. However, in the intervals from 1,100 to 1,108 ft bgs and 1,186 ft to 1,200 ft bgs the hydraulic conductivity is estimated to be over 3 gal./day/ft^2.

7.0 WELL DESIGN AND CONSTRUCTION

R-26 was installed as a hydrogeologic characterization and groundwater monitoring well as part of LANL's Groundwater Protection Program and in accordance with the "Hydrogeologic Workplan" (LANL 1998). On October 17, 2003, KA received final construction specifications for R-26 following approval of the design by DOE, LANL, and NMED. Well installation activities were performed from October 17 to 21, 2003. Sections 7.1 and 7.2 describe the main aspects of well design and construction, respectively. Section 7.3 discusses the completion of two piezometers in the corehole.

7.1 Well Design

Well design was undertaken jointly by DOE, LANL, and KA, and NMED approved the well design before well construction. Data from geophysical logs, borehole video logs, borehole geologic samples, field water level and water quality measurements, and field observations were analyzed to determine the appropriate intervals to be screened. Two well screen intervals were specified for R-26: (1) an upper screen to monitor groundwater associated with an intermediate zone of perched saturation and (2) a lower screen to monitor potential contaminants in the uppermost productive zone of the regional aquifer. The planned well design assumed a typical two-section, rod-based screen length of approximately 23 ft. However, a two-section, pipe-based screen with a perforated length of 18 ft was used for the upper screened interval. In addition, the blank casing length between the two screened intervals is approximately 4 ft shorter than the design due to the limitations of available casing joint lengths. The planned design and actual constructed screen locations for R-26 are listed in Table 7.1-1.

Table 7.1-1
Summary of Well Screen Information for Well R-26

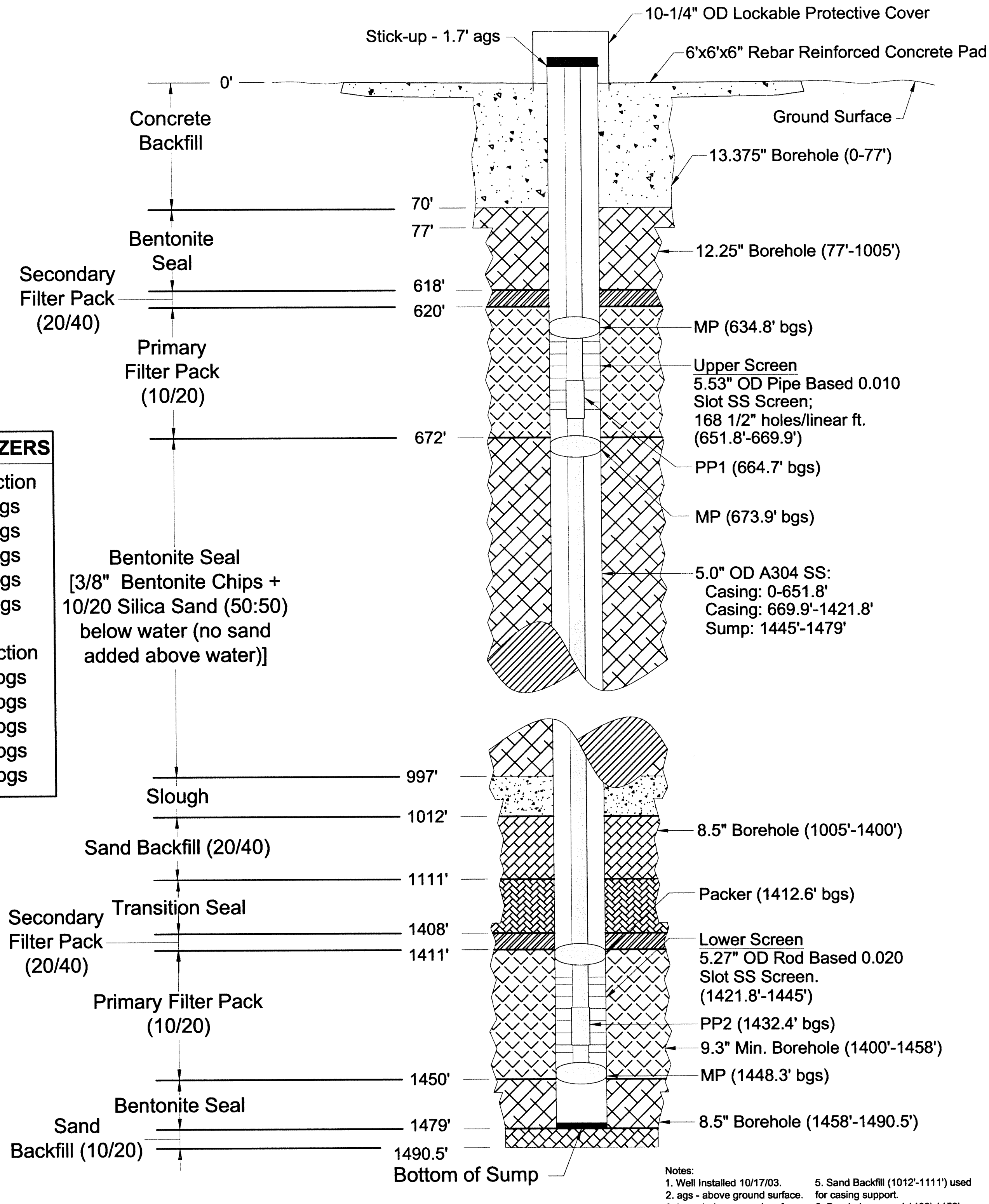
Screen No.	Planned Depth (ft bgs)[a]	Actual Depth (ft bgs)[a]	Geologic/Hydrologic Setting
1	643–666	651.8–669.9	Intermediate perched zone in the Cerro Toledo interval of the Bandelier Tuff
2	1422–1445	1421.8–1445	Regional zone of saturation in the Puye Formation

[a] These intervals represent the perforated area of the screen.

7.2 Well Construction

R-26 was constructed of 4.46-in. inner diameter (ID)/5.0-in.-OD, type A304 stainless-steel casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. The upper screen was constructed of two 10-ft joints of wire-wrapped 5.53-in.-OD, pipe-based 0.010-in. slotted well screens. The lower screen was constructed using 5.27-in.-OD, rod-based 0.020-in. slotted screens. Stainless-steel casing was installed below the lower screen to provide a 34-ft-long well sump. Figure 7.2-1 is a schematic as-built diagram of the completed R-26 well.

External couplings, also of type A304 stainless steel fabricated to ASTM A312 standards, were used to connect individual casing and screen joints. Centralizers were installed above and below



CENTRALIZERS

Upper Section
347 ft. bgs
529 ft. bgs
620 ft. bgs
659 ft. bgs
670 ft. bgs

Lower Section
1086 ft. bgs
1298 ft. bgs
1420 ft. bgs
1432 ft. bgs
1446 ft. bgs

Notes:
1. Well Installed 10/17/03.
2. ags - above ground surface.
3. bgs - below ground surface.
4. Screen depths are slotted intervals.
5. Sand Backfill (1012'-1111') used for casing support.
6. Borehole reamed 1400'-1458'.
7. Drill Casing removed prior to well installation
8. Westbay installed: 7/16/05
9. MP - Packer / PP - Port

KLEINFELDER		WELL SCHEMATIC DIAGRAM Well R-26 Los Alamos National Laboratory Los Alamos, New Mexico	FIGURE **7.2-1**
Drawn By: C. Landon	Date: January 2005		
Project No.: 37151	Filename: Figure 7.2–1.dwg		
Scale: not–to–scale	Revision: 0		

each joint of well screen. In addition, one centralizer was placed approximately 100 ft above each screen interval. Centralizers for R-26 are located at 347 ft, 529 ft, 620 ft, 659 ft, 670 ft, 1,086 ft, 1,298 ft, 1,420 ft, 1,432 ft, and 1,446 ft bgs (Figure 7.2-1).

The casing and screens were factory-cleaned before being shipped and delivered to the site. Additional decontamination of the stainless-steel components was performed onsite using a high-pressure steam cleaner and scrub brushes. Annular fill was placed in casing/borehole annulus through use of a tremie pipe. Well installation occurred on October 17, 2003, and backfilling was completed on October 21, 2003.

7.2.1 Steel Installation

R-26 well steel installation consisted of connecting joints of stainless-steel casing and screen sections by means of external threaded couplings. The bottom of the well was set at 1,479 ft bgs. Figure 7.2-1 shows the as-built well configuration and indicates the depths of the various well components as measured from ground surface.

7.2.2 Annular Fill Placement

Placement of annular fill consisted of using a 2.5-in. OD steel tremie pipe to deliver various materials to specified backfill intervals. Filter packs across screened intervals consisting of silica sand were generally transported using municipal water and placed in the annulus as a fluid slurry. Bentonite materials were placed between screened intervals to seal the annular space and to isolate the water-bearing zones.

The bottom of the open R-26 borehole was measured at 1,490.5 ft bgs before beginning backfill activities. Well casing and screens were lowered in the hole, and the bottom of the sump was positioned at 1,479 ft bgs. The lower part of the borehole was backfilled with 10/20 silica sand from 1,490.5 ft (TD) to 1,479 ft bgs, and bentonite chips were then tremied in the annulus from the top of the sand to 1,450 ft bgs to create a seal around the well sump. A primary filter pack consisting of 10/20 silica sand was placed across the lower screen in the annular interval from 1,450 to 1,411 ft bgs, and a secondary filter pack of 20/40 silica sand was placed above the screen from 1,411 to 1,408 ft bgs. A swabbing tool was run through the screened interval to settle the primary filter pack before placement of the secondary filter pack. Next, a transition seal was placed above the secondary filter pack in the annular space between 1,408 and 1,111 ft bgs. The transition seal consisted of a 50:50 mixture of 10/20 sand and bentonite chips.

To provide casing support, 20/40 silica sand backfill was placed above the transition seal from 1,111 to 1,012 ft bgs. After placing the transition seal, 15 ft of formation material was sloughed into the annulus. A bentonite seal was installed above the backfill sand from 997 to 672 ft bgs. A primary filter pack consisting of 10/20 silica sand was then tremied across the upper screen interval from 672 to 620 ft bgs, followed by a secondary filter pack of 20/40 silica sand from 620 to 618 ft bgs. A swabbing tool was run through the screened interval to settle the primary filter pack before placement of the secondary filter pack. A final bentonite seal was then placed above the secondary filter pack from 618 to 70 ft bgs. Concrete backfill, consisting of 2,500 pounds per square inch (psi) concrete with 4 percent bentonite, was placed from 70 ft bgs to near the surface. Approximately 16,000 gal. of water were used during well completion. The quantities of annular fill materials used in the completion of R-26 are presented in Table 7.2-1.

Table 7.2-1
Annular Fill Materials Used in Well R-26

Function/Material	Amount	Unit[a]	Mix
Backfill: 10/20 sand	10	Bag	–
Seal: ⅜-in. bentonite chips	15.5	Bag	–
Primary filter pack, lower screen: 10/20 sand	15.5	Bag	–
Secondary filter pack, lower screen: 20/40 sand	1	Bag	–
Transition seal: 10/20 sand and bentonite	65 sand/34 bentonite	Bag/5-gal. bucket	50:50
Backfill: 20/40 sand	56	Bag	–
Seal: ⅜-in. bentonite chips	5.875	Bag	–
Primary filter pack, upper screen: 10/20 sand	70	Bag	–
Secondary filter pack, upper screen: 20/40 sand	5	Bag	–
Seal: ⅜-in. bentonite chips	7.75	Supersack	–
Surface seal: concrete backfill	2	Cubic Yards	2,500 psi concrete with 4% bentonite
Potable water	15,978	Gallons	–

[a] Sand bag = 45 lb each, bentonite bag/bucket = 50 lb ea, bentonite supersack = 3,000 lb ea (equivalent to 3 yd^3)
Sand bag = 0.5 ft^3 each, bentonite bag/bucket = 0.67 ft^3, bentonite supersack = 41.4 ft^3

7.3 Piezometer Construction

Two piezometers were installed in the open 8½-in. R-26 corehole to monitor two potential zones of perched saturated water observed during Phase I drilling. Piezometer construction was performed on October 1, 2003. Piezometers 1 and 2 were completed using 1-in. OD, Schedule 40 flush-jointed polyvinyl chloride (PVC) casing and 0.010-in. slotted screen. PZ-1 was screened across the interval from 230 to 250 ft bgs. A filter pack of 10/20 silica sand was tremied across the screened interval from 250 to 225 ft bgs, and a bentonite seal was then placed from 225 to 185 ft bgs. PZ-2 was constructed above the bentonite seal with its screen positioned from 150 to 180 ft bgs and sump from 180 to 185 ft bgs. The PZ-2 filter pack of 10/20 silica sand was installed from 185 to 145 ft bgs, and a bentonite seal was placed from 145 to 60 ft bgs. The annular interval from 60 to 2 ft bgs was backfilled with bentonite, and concrete was poured from 2 ft bgs to ground surface. A total of 14 bags of 10/20 silica sand and 41.5 bags of bentonite chips were used in constructing the two piezometers. Figure 7.3-1 is a schematic as-built diagram of these piezometers.

8.0 WELL DEVELOPMENT AND HYDROLOGIC TESTING

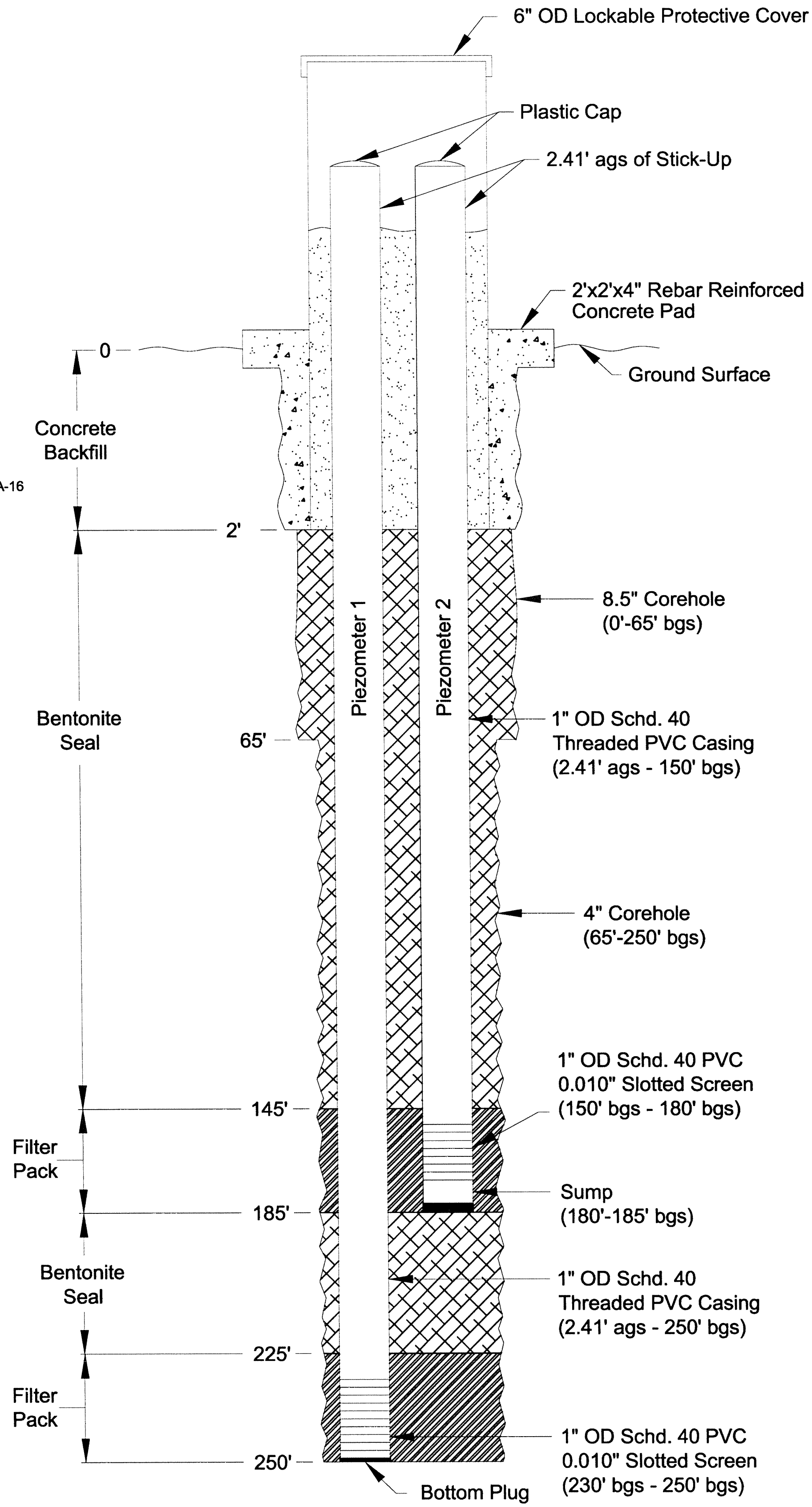
Well development activities at R-26 were conducted from October 18, 2003, to November 17, 2003. Well development procedures, described below, included airlifting, well-screen swabbing,

Location: Mesa South of Cañon de Valle
(on down thrown side of Pajarito Fault) TA-16

Survey Coordinates / Elevations:
- Coordinates: NAD83
- Elevation: NGVD29

Description: Core Hole Piezometer 1
Northing: 1764660.49
Easting: 1610201.92
Elevation Top of Casing: 7641.95'

Description: Core Hole Piezometer 2
Northing: 1764660.61
Easting: 1610201.96
Elevation Top of Casing: 7641.95'



LEGEND:

- **Bentonite Seal** (Bentonite Chips, Hydrated)
- **Filter Pack** (10-20 Silica Sand)
- **Concrete**
- **10-20 Silica Sand**

Keyed Notes:

1. Completion Date: 10-01-03
2. bgs: below ground surface
3. ags: above ground surface

KLEINFELDER

Drawn By: C. Landon	Date: January 2005
Project No.: 37151	Filename: Figure 7.3-1.dwg
Scale: not-to-scale	Revision: 4

SCHEMATIC DIAGRAM
Corehole Piezometers Well R-26
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
7.3-1

surging, bailing, and pumping, and also, during well construction, surging was done to encourage settlement of the filter packs. A total of 55,294 gal. of water were removed during well development and hydrologic testing. All produced fluids were stored in lined pits and storage tanks until discharge approval was received from NMED.

Hydrologic testing consisted of two constant rate pumping tests and one falling head test. The tests were conducted from February 16 to February 20, 2004. Results from these tests are in Appendix A of the Addendum to this report (Kleinfelder 2004).

8.1 Well Development

Well development at R-26 was performed in three stages. The initial stage consisted of airlifting to remove excess drilling fluids and to allow for formation water to recharge the well. The second stage consisted of bailing to remove solid materials from the well, followed by swabbing and surging the screened intervals to draw fine sediment from the constructed filter pack. The final stage consisted of lowering a submersible pump into the well and drawing the pump repeatedly across the screened intervals.

The efficiency of well development was monitored by measuring field water-quality parameters (pH, temperature, specific conductance, and turbidity). To monitor progress during each development stage, samples of water were periodically collected and parameter measurements were recorded in the field log book and on field forms. The field log book and forms are on file at KA's Albuquerque office, and copies will be included in the LANL record project file.

The primary objective of well development was to remove suspended sediment from the water until turbidity was less than 5 NTUs for three consecutive samples. Similarly, other measured parameters were required to stabilize before terminating development procedures. In addition, total organic carbon (TOC) samples were collected and analyzed toward the end of development. The target level for TOC was 2 parts per million. Table 8.1-1 presents the final water quality parameter data values measured during the well development process.

Preliminary bailing from the R-26 screened intervals and sump was performed to remove bentonite materials, drilling fluids, and formation sands and fines that had been introduced into the well during drilling and installation. Bailing activities were conducted by WDC using a 5-gal. capacity, 3-in.-diameter by 10-ft-long stainless-steel bailer. Bailing activities continued until water clarity improved. Bailing was followed by swabbing across each screened interval to enhance filter-pack development. A swabbing tool consisting of a 4.25-in.-diameter, 1-in.-thick rubber disc attached to the drill rod was lowered into the well and was drawn repeatedly across the screen interval for approximately one hour. Water turbidity was not measured during the bailing and swabbing process.

Table 8.1-1
Development and Testing of Well R-26

Method	Water Removed (gal.)	pH	Temperature (°C)	Specific Conductance (μS/cm)[a]	Turbidity (NTU)
Airlifting	3,872	NM[b]	NM	NM	NM
Bailing/Swabbing Screens	123	7.92	12.7	146	NM
Pumping Upper Screen	5,899	NM	16.8	80	4.87
Pumping Lower Screen	25,210	NM	17.2	80	4.58
Sump	5,965	NM	NM	NM	NM
Hydrologic Testing	14,225	NM	NM	NM	NM
Total	55,294				

[a] Specific conductance is reported in microsiemens per centimeter
[b] NM = Not measured

Following swabbing, pump development procedures were applied to the screened intervals (651.8 to 669.9 ft bgs and 1421.8 to 1445 ft bgs) using a 10 horsepower, 4-in. Grundfos submersible pump. The pump intake was lowered to each screened interval and was cycled on at a nominal rate of 6.0 gal. per minute. The pump intake was then drawn across the length of each screened interval to remove remaining fines from the filter pack and adjacent formation. While pumping, water samples were collected for parameter measurements. Once the target water quality parameters were reached (<5 nephelometric turbidity units [NTUs]), the pump was tripped out and the packer, which isolates the screens from one another, was placed above the pump. Initially, the upper screen was pumped with the packer located below the pump. The lower screen and sump were then pumped. Pump development was then completed with additional pumping of the upper screen.

Figure 8.1-1 illustrates the effects of well development in the upper screen on measured field parameters. Figure 8.1-2 illustrates the effects of well development in the lower screen on measured field parameters. R-26 was considered fully developed when the limiting values of acceptability were met. The primary acceptance criterion was that turbidity be less than 5 NTUs.

From July 10 to July 14, 2004, additional well development was conducted at well R-26 prior to the installation of the Westbay Multi-Port (MP) sampling system. A 10 horsepower, 4-in. Grundfos submersible pump was used to pump the well from 1,209 and 1,467 ft bgs prior to sampling. The upper depth was pumped continuously between 10:45 A.M. on July 11, 2004 and 11:57 A.M. on July 13, 2004 and a total of 41,818 gallons (gal.) of water were removed. The lower depth was pumped between 2:40 P.M. and 6:10 P.M. on July 13, 2004, and an additional 3,733 gal. of water were removed.

After the additional well development, a downhole video log was run to observe casing conditions and water clarity prior to the installation of the sampling system. Appendix A, Borehole Video

Logs, contains a DVD of the R-26 borehole video log as well as the corehole video log from the shallow corehole at R-26.

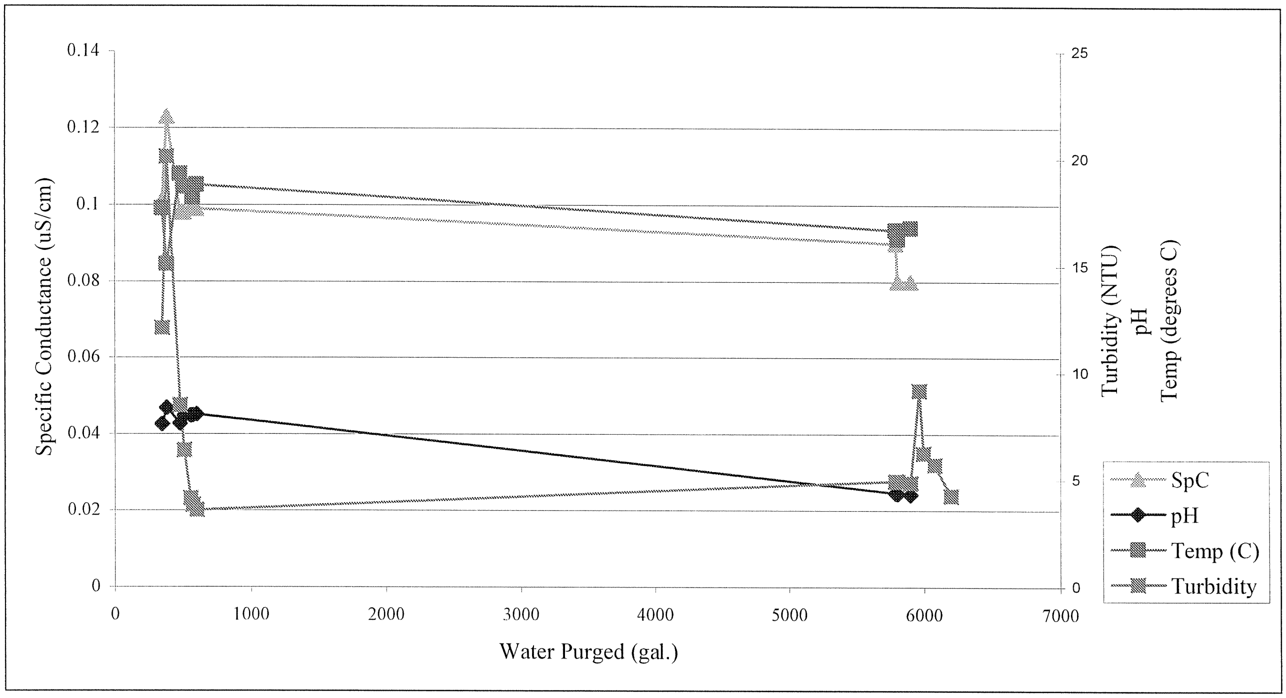


Figure 8.1-1. Effects of Pump Development of the Upper Screen on Water Quality Parameters at Well R-26

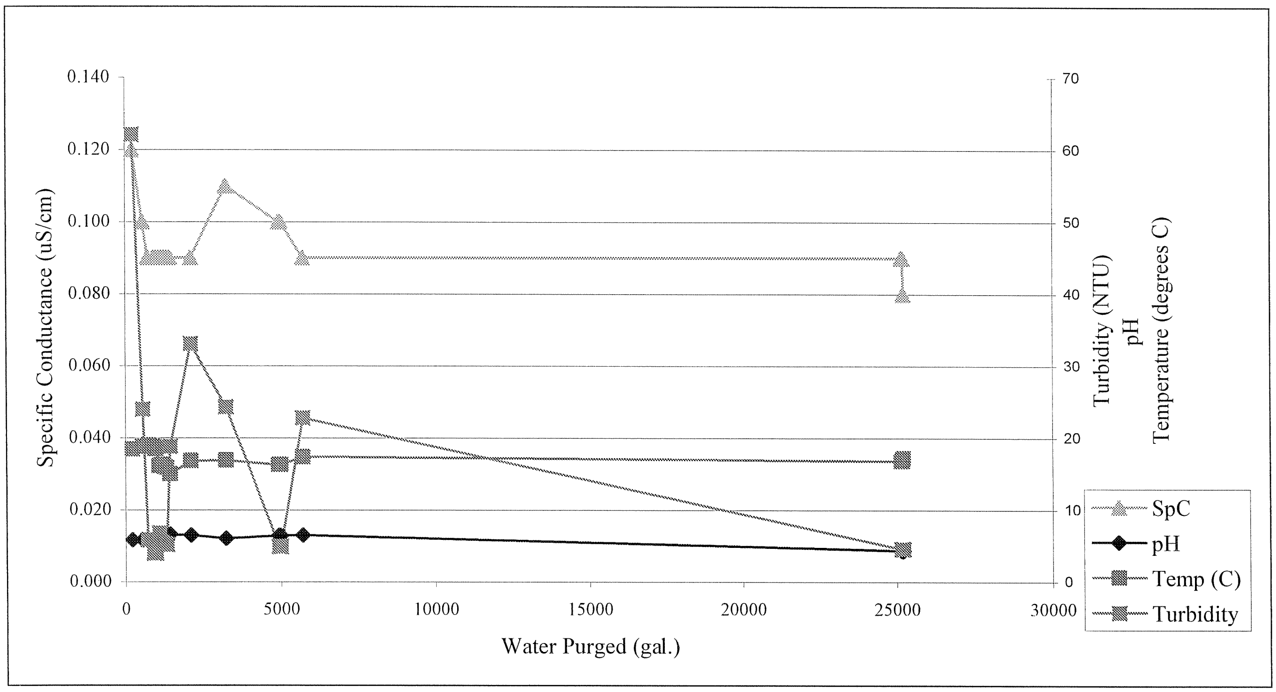


Figure 8.1-2. Effects of Pump Development of the Lower Screen on Water Quality Parameters at Well R-26

8.2 Hydrologic Testing

Constant-rate pumping tests and shut-in tests were conducted on the two water-bearing zones in R-26 from February 16, 2004, and March 6, 2004. The purpose of the tests was to determine the hydraulic properties and lateral extent of the two water-bearing zones encountered in R-26. One aquifer test was conducted on the upper intermediate zone, with a screened interval from 651.8 to 669.9 ft bgs, and two tests were conducted on the lower regional zone, screened between 1421.8 to 1445 ft bgs.

The average hydraulic conductivity of the upper zone, in the Cerro Toledo interval, adjacent to the borehole, is approximately 1.7 ft per day. Further from the borehole, average hydraulic conductivities ranged between 2.4 and 3.7 ft per day, depending on the degree of anisotropy. A steep vertical gradient was observed over this interval, suggesting that values in the upper end of the range may be most reliable. The results of the aquifer test on the upper interval indicate that it is limited in areal extent and not well connected to the lower regional aquifer.

The aquifer tests revealed that the lower water-bearing zone, in the Puye Formation fanglomerate, is a much less permeable zone with an average hydraulic conductivity of 0.0022 ft per day, with a lower bound of 0.002 ft per day. The complete report summarizing these tests is included as a compact disc (CD) in Appendix E.

8.3 Dedicated Sampling System Installation

Following final well development activities, a Westbay Instruments, Inc., multi-port sampling system was installed in R-26 to isolate and allow discrete sampling of the two water-bearing zones. Appendix F to this report contains a CD with a PDF file of the complete Installation Report compiled by Westbay Instruments, Inc.

8.4 Wellhead Completion

The surface completion for R-26 involved placing a reinforced (2,500 psi) concrete pad, 6-ft wide by 6-ft long by 6-in. thick on December 19, 2004. A brass survey pin was installed in the northwest corner of the pad. A 10.75-in. steel casing with locking lid protects the well riser. The pad was designed to be slightly elevated, with base course graded up around the pad to allow for drainage. Bollards were installed during site restoration activities.

Some fissures developed in the concrete wellhead surface pad that was installed, necessitating repair and refurbishment of the concrete pad. The refurbishment was completed on October 25, 2004. The specifications for the wellhead pad are the same as those for the previous wellhead.

8.5 Geodetic Survey

The refurbished wellhead pad was resurveyed on October 27, 2004. The brass cap monument in the concrete pad and the top of the stainless-steel well casing were resurveyed; the new coordinates for these features are shown in Table 8.5-1.

Table 3.5-1

Coordinates for New Wellhead Features at R-26 and Piezometers

Description	Northing[a]	Easting[a]	Elevation[b]
Brass cap in R-26 Pad	1764721.12	1610267.33	7641.69
Top of stainless-steel casing	1764721.35	1610269.56	7643.33
PZ 1 (185 ft TD)	1764660.49	1610201.92	7641.95[(c)]
PZ 2 (250 ft TD)	1764660.61	1610201.96	7641.95[(c)]

[a] Coordinates are NM State Plane Grid, Central Zone, NAD83, determined from LANL monument A1601with static Global Positioning Satellite observation.

[b] Feet above mean sea level relative to the National Geodetic Vertical Datum of 1929.

8.6 Site Restoration

On December 12, 2003, a Notice of Intent (NOI) to discharge drilling and development water from the borehole-cuttings containment area at R-26 was forwarded, via e-mail, to Mr. Curt Frishkorn with the NMED. Approval to discharge drilling and development water was received via e-mail from the NMED on January 14, 2004. A copy of the e-mail received from the NMED is in Appendix G.

Fluids produced during drilling and development were sampled in accordance with the NOI to Discharge, Hydrogeologic Workplan Wells and filed with the NMED. Results of the sampling data were reviewed by the NMED and LANL, and discharge was approved. A copy of the sample analysis is included in Appendix A of the Addendum to this report (Kleinfelder 2004).

Water from the borehole-cuttings containment area has been land-applied in the area of the general drill site using a 2,000-gal. capacity water truck. Silt fencing and straw bales have been left in place to minimize possible sediment impacts from future precipitation.

Site restoration activities included removing the polyethylene liner and borehole cuttings from the borehole-cuttings containment area, removing the containment area berms, and backfilling and grading the containment area. The cuttings were thinly spread onsite after obtaining NMED-approval.

The former drill site was graded, seeded with native vegetation, and mulched. Native vegetation has been re-established with 70% coverage. The Best Management Practices for the site, per the National Pollution Discharge Elimination System permit, included temporary site fencing to minimize silt runoff from the site. DOE filed a Notice of Termination on October 29, 2004 and the temporary site fencing to control silt runoff was removed on November 14, 2004.

9.0 DEVIATIONS FROM THE R-26 SAP

Appendix H compares the actual characterization activities that were performed at R-26 with the planned activities described in the "Hydrogeologic Workplan" (LANL 1998, 59599) and the R-26 SAP (LANL 2003, 03-4782. The main deviations from planned activities are summarized below:

- Planned depth – the SAP stated that the approximate depth of the well would be 1414 ft bgs. The completed borehole TD was 1490.5 ft bgs to ensure that the top of the regional aquifer was penetrated.
- Number of core and cuttings samples collected for contaminant analysis – up to 15 samples from the unsaturated zone and two samples each from saturated zones were planned for as specified in the R-26 SAP; 13 were actually collected. Use of drilling fluids precluded the collection of cuttings for contaminant characterization within the zones of saturation.
- Piezometer installation – piezometer installation was not specified in the SAP. Two temporary piezometers were installed in the corehole to monitor perched water conditions. Details about piezometer installation are presented in Section 7.3.
- Drilling methods -- The borehole was reamed across the lower screen interval to increase the diameter of the hole.

10.0 ACKNOWLEDGEMENTS

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EnviroWorks, Inc provided site preparation and restoration activities.

Lynn Engineering & Surveying, Inc. provided the final geodetic survey.

N. Clayton of Schlumberger provided processing and interpretation of borehole geophysical data.

P. Longmire of LANL contributed the geochemistry section of this report.

Tetra Tech EM, Inc. provided support for well site geology, sample collection, and hydrologic testing.

WDC Exploration & Wells provided rotary drilling services.

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